

Taxonomy and stridulation of the Gomphocerinae and Truxalinae of Thailand (Orthoptera, Acrididae)

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Taxonomy and stridulation of the Gomphocerinae and Truxalinae of Thailand (Orthoptera, Acrididae). – Four species of Gomphocerinae and one of Truxalinae are recorded from Thailand: *Dhimbana castanea* sp.n., *Paragonista hyalina* Ingrisch, 1989, *Dnopherula* (A.) *taeniatus* (Bolívar, 1902), *Dnopherula* (A.) *svenhedini* (Sjöstedt, 1933) and *Truxalis siamensis* Dirsh, 1950. The female of *P. hyalina* is described for the first time; *T. siamensis* is redescribed; the high morphological variability of both *Dnopherula* species is demonstrated. For all 5 species, stridulation is described for the first time.

Key-words: Orthoptera - Acrididae - Thailand - Taxonomy - Stridulation.

INTRODUCTION

Grasshoppers of the subfamilies Gomphocerinae and Truxalinae (used here in the sense of DIRSH 1961, 1975 and UVAROV 1966) are scarcely represented in the fauna of Indochina. Previous records from Thailand comprise only three species: *Aulacobothrus luteipes* (Walker, 1871) (ROFFEY 1979), placed in *Dnopherula* by JAGO (1971), *Paragonista hyalina* Ingrisch, 1989 and *Truxalis siamensis* Dirsh, 1950. However, recent studies showed that the first consists in reality of two species, *D. luteipes* with a restricted distribution in India and *D. taeniatus* (Bolívar, 1902) which is widespread in the Oriental region (INGRISCH in press). Both were erroneously synonymised by UVAROV (1921). *P. hyalina* has been known in the male sex only, and *T. siamensis* from the female type and a pair of doubtful origin.

Sporadic excursions from 1985 - 1993 showed that four Gomphocerinae and one Truxalinae species occur in Thailand. Apart from the species mentioned above,

Dnopherula svenhedini (Sjöstedt, 1933), the previously unknown female of *P. hyalina* and an undescribed species of the Indian genus *Dhimbana* Henry, 1940 were recently collected. Moreover, it proved that *T. siamensis* was insufficiently described by DIRSH (1950).

In Gomphocerinae and Truxalinae, the variation of the individuals within a species or even within a local population is usually high, the differences between closely related species low. Thus, differentiation of the species on morphological characters is often difficult, and even the genital structures are rather uniform between and within genera (DIRSH 1956). In those subfamilies, separation of the species is mainly based on behavioural characteristics.

Gomphocerinae and Truxalinae are characterised by the possession of stridulatory pegs on the inner surface of the postfemur which are rubbed against the radial vein of the tegmen during sound production. The songs differ between species and are a powerful tool in the recognition of the species. Our knowledge of the stridulation of the Gomphocerinae and Truxalinae of the Oriental region, however, is only at the very beginning.

The aim of the present paper is to update the systematics of all species of Gomphocerinae and Truxalinae hitherto found in Thailand. Emphasis is laid on presenting the great intra-population variability of some morphological characters previously thought to be of taxonomic value and on introducing stridulation as a new character for the separation of the Oriental Gomphocerinae.

METHODS

Morphological studies and measurements were done with a WILD M5 stereo microscope using an ocular micrometer; for drawings a camera lucida was used with the same stereo microscope. Apart from standards the following measurements were taken:

H e a d : width of fastigium between the front margins of the compound eyes and including the lateral carinulae; **eye length**: the longest diagonal diameter in lateral view; **length of suborbital furrow**; **length of fastigium in lateral view** from the tip of the head to the front margin of the compound eye. **P r o n o t u m** : length along the median carina; **length of prozona** along the median carina from the front margin to the principal sulcus. **T e g m e n** : apical field, from the point where the subcosta meets the costa to the tip of tegmen (sometimes difficult to evaluate in the ♀ and thus not always measured). **M e s o s t e r n u m** : width of mesosternal interspace and width of mesosternal lobes, both at halfway the length of the interspace.

The terminology of the phallic complex used is as in DIRSH (1956).

Recording of stridulation: In the field, recording was done with a portable cassette recorder (SONY WM3) and a UNIVERSUM microphone on CrO₂-tape cassettes; resulting frequency range 0.05 - 15 kHz. In the studio, stridulation was recorded with a cassette recorder (KENWOOD KX 880 HX) and an AKG D202 microphone with the low frequency range (< 100 Hz) switched off on pure metal tape cassettes. The resulting frequency range was 0.1 - 20 kHz. During studio recording,

the grasshoppers were kept in wooden cages with gauze walls. A 60-Watt-bulb provided light and radiation heat.

Oscillographs were produced by an Oscillomink (Fa. Siemens) after rerecording on an UHER Report M4200 tape recorder.

For the description of songs the following terminology is used: *syllable*, one complete down and up movement of the hind legs; *echeme*, first order assemblage of syllables; *verse* (= echeme sequence in RAGGE 1987, RAGGE & REYNOLDS 1988), first order assemblage of echemes.

Most material was personally collected during excursions in 1985 - 1993. Unless otherwise stated, the material is in my collection.

SYSTEMATIC PART

KEY TO THE SPECIES OF GOMPHOCERINAE AND TRUXALINAE OF THAILAND

- 1 Postfemur with a row of stridulatory pegs (and/or bristles) on internal surface. 2
- Postfemur without stridulatory pegs on internal surface. . . . other subfamilies
- 2 Head strongly elongate with eyes near the apex (fig. 25); distance eyes - pronotum more than twice the longest diameter of one eye. Truxalinae:
 - *Truxalis siamensis* Dirsh, 1950
- Head not so extremely elongate, if strongly reclinate (figs 21-22) then the distance eyes - pronotum not more than the longest diameter of one eye. Gomphocerinae 3
- 3 Head strongly reclinate, distinctly conical, with a shallow triangular impression at the front margin of the compound eye (figs 21-22). 4
- Head slightly reclinate to bulbous, with rectangular foveolae (figs 23-24). . . . 5
- 4 Fastigium verticis in front of the eyes 0.7 - 0.9 x the longest diameter of one eye; antennae inserted in front of lateral ocelli (fig. 3); vertex with a strong median carina (figs 1-2). Tegmen shorter than abdomen. Brown with a dorso-medial and on each side with a ventro-lateral white band (figs 1-2, 21-22). *Dhimbana castanea* n.sp.
- Fastigium verticis in front of the eyes 0.6 - 0.7 x the longest diameter of one eye; antennae inserted between the anterior margins of the lateral ocelli (fig. 6); vertex with a faint median carinula (figs 4-5). Tegmen longer than abdomen. Coloration different, without a dorso-medial white band. *Paragonista hyalina* Ingrisch, 1989
- 5 ♀ stout. Antennae slender, in ♂ surpassing base of postfemur. Sulcus often slightly behind the middle of pronotum (figs 7-11) (but sometimes in or slightly before the middle), index prozona : metazona = 0.93 - 1.22 (mean = 1.06). Tegmen indistinctly mottled, with small spots in medial area, in ♂ with costal area wider, apical area rather narrow, and cubital field slightly widened (figs 45-47). Posttibia with ventral interno-apical spur only slightly longer than dorsal spur (fig. 26).
 - *Dnopherula (Aulacobothrus) taeniatus* (Bolívar, 1902)

- ♀ slender. Antennae stronger, in ♂ not reaching base of postfemur. Sulcus slightly before or in the middle of pronotum (figs 12-15), index prozona : metazona = 0.84 - 1.00 (mean = 0.94). Tegmen distinctly mottled, with large spots in medial area, in ♂ with costal area less widened, apical area broad, and cubital field not widened (figs. 49-50). Posttibia with ventral interno-apical spur much longer than dorsal spur (fig. 27). *Dnopherula (Aulacobothrus) svenhedini* (Sjöstedt, 1933)

DESCRIPTION OF SPECIES AND STRIDULATION

Dhimbana castanea n.sp. (Figs 1-3, 21-24, 29, 30, 36, 52-53, 56-58, 64)

Holotype, ♂: Thailand, Chiang Mai province, W Chiang Mai, near Huei Kaeo waterfall at the foothills of Doi Suthep. 26.IV.1988 lg. Ingrisch (Muséum d'Histoire naturelle de Genève).

Paratypes: 1 ♀, Thailand, Chiang Mai, Huei Kaeo 12.IV.1985; 1 ♂, 1 ♀ (allotype), do. 26.IV.1988; 2 ♂, 3 ♀, do. 3.V.1988; 2 ♂, 1 ♀, do. 10.IX.1989; 1 ♂, do. 3.X.1991; 1 ♂, 4 ♀, do. 4.-7.VIII.1992 (allotype ♀, Muséum d'Histoire naturelle de Genève; 2 ♂, 2 ♀, Department of Agriculture Bankhen, Bangkok; rest in my collection).

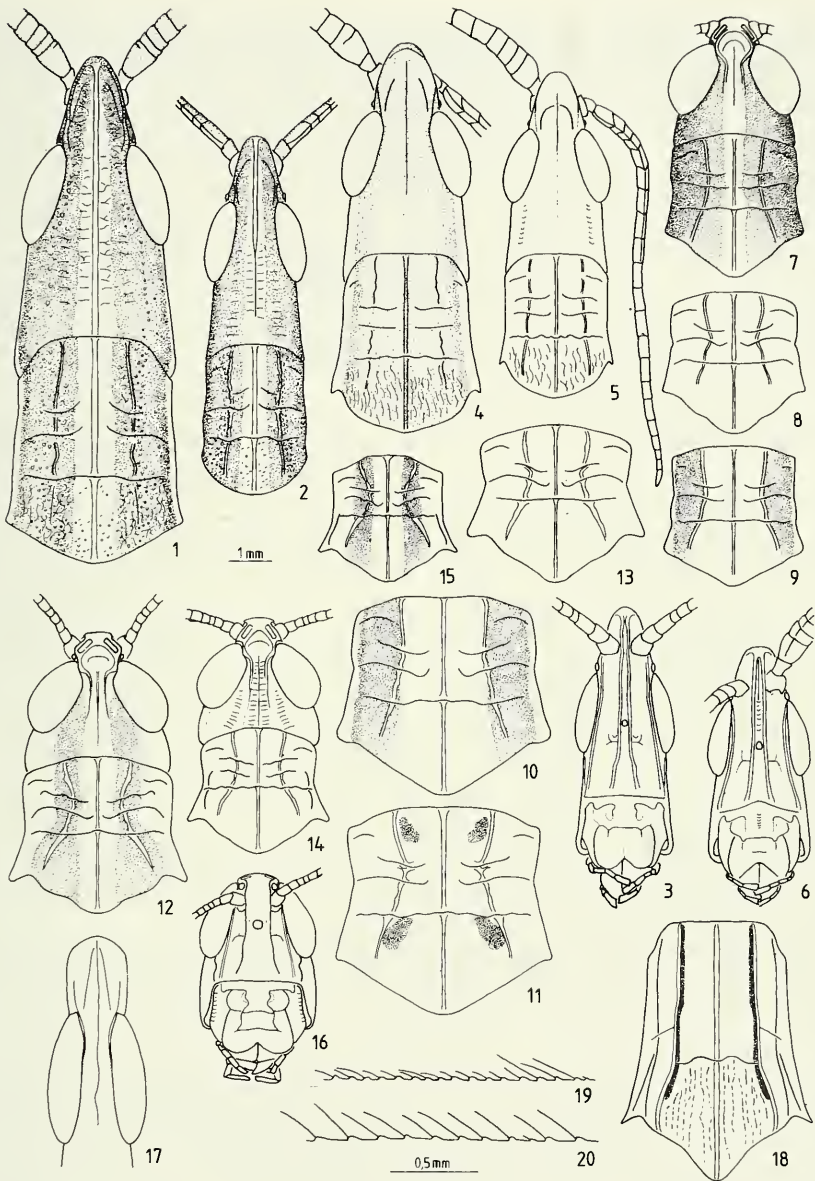
Other material: 1 ♀, Prachuap Khiri Kan province, Hua Hin, hill near golf course, 26.VII.1992; 2 ♂, 2 ♀, do. 1.IV.1993.

Habitat: Open grassy spots in a mixed rock-savanna-teak forest habitat.

Description. Head (figs 1-2, 21-22) elongate, conical, longer than pronotum; fastigium verticis distinctly projecting in front of the eyes, with a median carina which is distinct in front of the eyes, gradually fading behind. A shallow triangular impression in front of dorso-anterior margin of compound eye; a faint additional carinula below lateral ocellus. Frontal carinae subparallel above, diverging below median ocellus (fig. 3). Vertex with transverse rugosities and longitudinal rows of punctures. Antennae longer than head and pronotum together, in male surpassing base of posterior femur; segments 3 - 8 or 9 (♂) respectively 3 - 12 or 13 (♀) in cross-section triangular and dorsally expanded in an apically decreasing manner, remaining segments subcylindrical.

Pronotum (figs 1-2, 21-22) cylindrical, rugosely punctured, more densely in metazona; median carina distinct, interrupted by principal sulcus only, lateral carinae faint, with indication of additional carinulae bordering the median pale band; first sulcus lateral, second sulcus indicated at lateral carinae only, third sulcus on paranota and disc, interrupted on the latter, fourth (= principal) sulcus faint on paranota, distinct on disc. Tegmen surpassing apex of stretched postfemur but leaving abdominal apex uncovered; venation as in figs 52-53. Hind wings reaching apex of folded tegmen.

Prosternum without distinct tubercle. Sternal plate (figs 36, 37) finely stippled; mesosternal lobes 1.5-2.4 x broader than mesosternal interspace, interspace 1.4-2.3 x longer than wide; metasternal lobes contiguous. Tympanum ovoid, 1.3 - 1.9 x longer than broad, operculate in dorso-posterior half. Postfemur slender, not reaching apex of elongate abdomen. interior area with a row of 90 - 115 (♂) or 84 - 117 (♀) stridulatory pegs; genicular lobes rounded. Posttibia with dorso-external apical spine lacking.



FIGS 1-20.

1-3. *Dhimbana castanea* n.sp. (paratypes): 1. head and pronotum of ♀ in dorsal view; 2. do. of ♂; 3. head of ♂ in frontal view; 4-6. *Paragonista hyalina* Ingrisch: 4. head and pronotum of ♀ in dorsal view; 5. do. of ♂; 6. head of ♂ in frontal view; 7-11. *Dnopherula taeniatus* (Bolivar) from Huei Kao: 7. head and pronotum of ♂ in dorsal view; 8-9. pronotum of other ♂♂; 10-11. pronotum of ♀♀; 12-16. *Dnopherula svenhedini* (Sjöstedt): 12. head and pronotum of ♀ in dorsal view; 13. pronotum of another ♀; 14. head and pronotum of ♂ in dorsal view; 15. pronotum of another ♂; 16. head of male in frontal view; 17-20. *Truxalis siamensis* Dirsh ♂ from Huei Kao: 17. fastigium and eyes in dorsal view; 18. pronotum; 19-20. sector of stridulatory file on internal side of postfemur: 19. from end of basal third of postfemur, 20. from middle of postfemur.

♂: Tenth tergite continuous. Supra anal plate (fig. 30) elongate-triangular, apex rounded, with a median furrow bordered by rounded carinae and with diagonal, baso-external folds. Cerci long-conical, simple. Subgenital plate (fig. 29) elongate, conical, with a strong dorso-medial carina. Epiphallus (figs 57, 58) bridge-shaped; anchorae large, apex subobtusate or obtuse; outer lophi much larger than inner lophi, somewhat curved. Cingulum (fig. 56) with zygoma, rami and apodemes; apodemes rather short, rami almost completely thin-membranous and translucent. Basal and apical penis valves connected by a curved, unbroken flexure.

♀: Supra anal plate semi-ovoid with sloping sides, a transverse sulcus, and a medio-longitudinal furrow in or somewhat beyond basal half. Cerci short. Ovipositor short, simple, only slightly extending beyond apices of supra anal plate and paraproctes. Subgenital plate oblong, apex from obtuse-angular to almost semicircular with a small triangular expansion in the middle.

C o l o r a t i o n . Antennae, head, pronotum und tegmen dark chocolate brown, a dorso-medial whitish band running from fastigium to apex of tegmen, a lateral whitish band from base of antennae to base of postfemur; frons and ventral margin of pleurae medium to light brown; hidden tergites and underside of body yellowish brown or testaceous. Antennae with white tips. Anterior and medial legs and postfemur yellow, green or light brown; hind knees more or less darkened; posttibia yellowish brown with an indistinct tint of blue. Variation: the general colour can be light brown instead of dark brown; the dorso-medial white band and the postfemur and posttibia can be infumated to a varying degree.

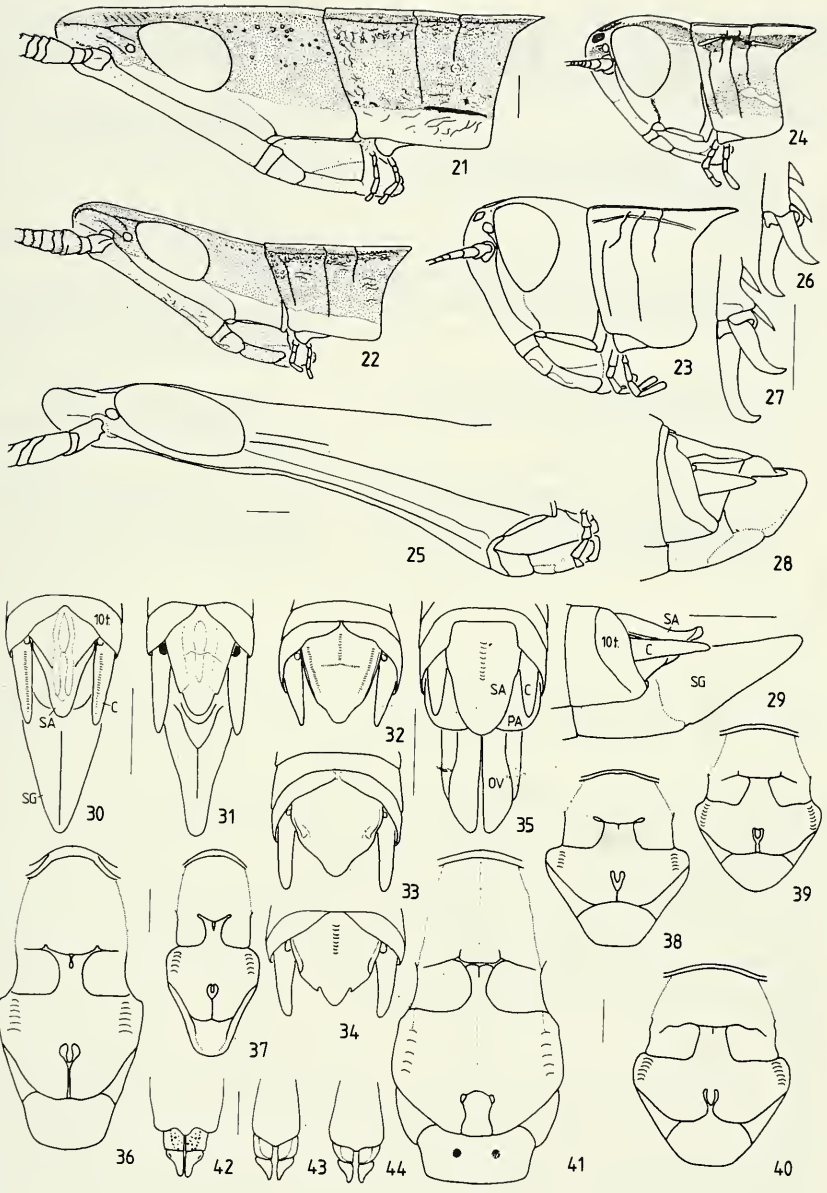
M e a s u r e m e n t s (length in mm): body ♂ 24 - 27, ♀ 30 - 36; fastigium (in front of eyes) ♂ 1.4 - 1.7, ♀ 1.8 - 2.2; antenna ♂ 12.0 - 14.0, ♀ 10.5 - 13.0; pronotum ♂ 3.4 - 3.8, ♀ 4.5 - 5.5; tegmen ♂ 14.5 - 17.0, ♀ 17.5 - 21.0; postfemur ♂ 9.5 - 10.5, ♀ 11 - 14.

Indices: Width of fastigium : eye length ♂ 0.52 - 0.58, ♀ 0.54 - 0.69; eye length : length of suborbital furrow ♂ 1.40 - 1.79, ♀ 1.33 - 1.65; length of prozona : length of pronotum ♂ 0.60 - 0.63, ♀ 0.61 - 0.67.

S t r i d u l a t i o n (fig. 64). The calling song consists of a single verse, and can be described as "tsick tick tick tick tick". Verse durations of (4 -) 10 - 20 s

FIGS 21-44.

21-24. head and pronotum in lateral view of 21. *Dhimbana castanea* n.sp. (paratype) ♀. 22. do. ♂, 23. *Dnopherula svenhedini* ♀, 24. do. ♂; 25. head of *Truxalis siamensis* Dirsh ♂ from Huei Kao in lateral view; 26-27. spurs at internal apex of posterior tibia of ♂ of 26. *Dnopherula taeniatus* (Bolívar); 27. *Dnopherula svenhedini* (Sjöstedt); 28-29. apex of abdomen of ♂ in lateral view of 28. *Dnopherula svenhedini* (Sjöstedt), 29. *Dhimbana castanea* n.sp.; 30-35. apex of abdomen in dorsal view of 30. *Dhimbana castanea* n.sp. ♂, 31. *Paragonista hyalina* Ingrisch ♂, 32. *Dnopherula svenhedini* (Sjöstedt) ♂, 33-34. *Dnopherula taeniatus* (Bolívar) two different ♂ ♂, 35. *Dnopherula svenhedini* (Sjöstedt) ♀; 36-41. meso- and metasternum of 36. *Dhimbana castanea* n.sp. ♀, 37. do. ♂, 38. *Dnopherula taeniatus* (Bolívar) ♂, 39. *Dnopherula svenhedini* (Sjöstedt) ♂, 40. do. ♀, 41. *Truxalis siamensis* Dirsh from Huei Kao ♂; 42-44. apex of subgenital plate of ♀ and ovipositor in ventral view of 42. *Dnopherula taeniatus* (Bolívar); 43-44. *Dnopherula svenhedini* (Sjöstedt). Scale = 1 mm (corresponding figures are always at the same scale). Abbreviations: 10t, tenth tergite, C cercus, OV ovipositor, PA paraproct, SA supra anal plate, SG subgenital plate.



have been recorded. Stridulation starts with a separate tsick-sound which is followed, after a pause of less than a second, by a prolonged echeme of uniform syllables. The syllables are double-pulses with the first pulse somewhat less loud than the second. They are repeated at a rate of about 6.5 per second (at 23°C + radiation heat). In the field, the males preferably used the pauses of a cicada choros to perform their songs.

D i s c u s s i o n . The name of the new species refers to the beautiful chocolate-brown coloration with white and green ornaments. *D. castanea* can be recognised by the peculiar shape of the body: face strongly reclinate, antennae ensiform, abdomen longer than tegmen or postfemur, and by the striking brown-white coloration. The genus *Dhimbana* HENRY, 1940, is not included in the revision of the Gomphocerinae by JAGO (1971); but according to an earlier paper it belongs to the *Mesopses* group (JAGO 1969). Two species have previously been placed in the genus, the type species *D. dawsoni* HENRY, 1940, and *D. indica* (UVAROV, 1932), the latter was originally described in *Brachycrotaphus* and is referred to as *Dhimbana* in UVAROV, 1943. Both species are strongly brachypterous. The new species differs from the above by much longer tegmina and hind wings. It can fly. Otherwise it is similar to *D. dawsoni*. Apart from the wing condition, it differs in having shorter antennae (at otherwise equal size of head and body), a shorter subgenital plate in the male, and in the ovipositor extending beyond the supra anal plate and the paraproctes in the female.

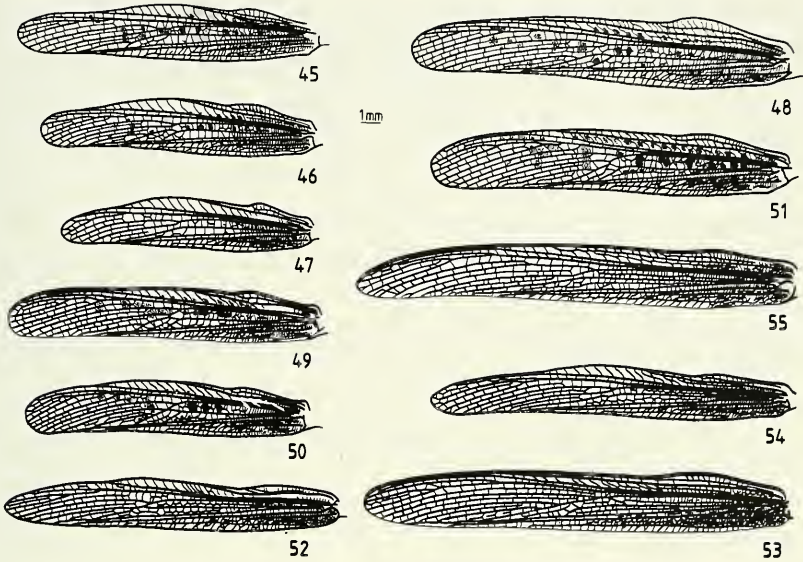
Paragonista hyalina Ingrisch, 1989

(Figs 4-6, 31, 54, 55, 59, 65)

Material studied: 2 ♂ (holotype + paratype), Thailand, Chiang Mai province, Huei Kaeo 12.IV.1985 (holotype in the Zoologische Staatssammlung; Munich); 1 ♂, 2 ♀, do. 30.IX.1985; 1 ♂ (paratype), do. 23.I.1987; 2 ♀, do. 26.IV.1988; 2 ♂, 3 ♀, do. 3.IV.1988; 1 ♂, do. 10.IX.1989; 1 ♂, do. 23.X.1990; 1 ♀, 7.VIII.1992.

D e s c r i p t i o n . Antennae (fig. 5) distinctly (♂) or faintly (♀) longer than head and pronotum together, ensiform, 3rd to 7th 9th (♂) respectively 3rd to 8th 12th (♀) articles widened, remaining articles subcylindrical. Face strongly reclinate. Frontal ridge prominent, in lateral view subconcave, projecting between antennae, sulcate, widening below median ocellus (fig. 6). Lateral fascial carinae curved. Fastigium verticis (figs 4, 5) projecting in front of eyes; vertex with a faint median carinula.

Pronotum (figs 4, 5) with median carina distinct, cut by the principal sulcus only, lateral carinae weak, substraight, cut by sulci 2-4; disc with posterior margin rounded or almost obtuse-angulate. Paranota longer than high. Prosternum slightly bulging. Mesosternal lobes with internal margin convex, 1.2-2.3 x wider than interspace; mesosternal interspace 1.2-2.1 x longer than wide; metasternal lobes contiguous. Tegmen (figs 54, 55) slender, reaching or surpassing middle of stretched hind tibia: costal and cubital areas slightly widened in ♂. Tympanum 1.6-2.3 x longer than wide. Legs rather short. Postfemur slender, internal area with a row of 134-188 (♂) or 126-165 (♀) stridulatory pegs; ventral genicular lobes rounded. Posttibia with external apical spine lacking; internal spurs of almost equal length.



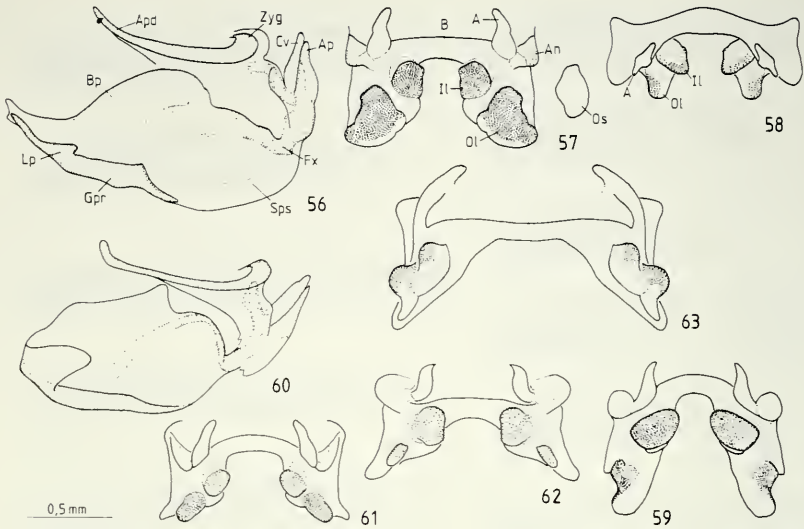
FIGS 45-55

Left tegmen of 45-47. *Dnopherula taeniatus* (Bolívar) ♂ (45, 46. Huei Kao, 47. Erawan); 48. do. ♀ (Huei Kao); 49-50. *Dnopherula svenhedini* (Sjöstedt); 51. do. ♀; 52. *Dhimbana castanea* n.sp. ♂ (paratype); 53. do. ♀; 54. *Paragonista hyalina* Ingrisch ♂; 55. do. ♀.

♂: Tenth tergite divided. Supra anal plate (fig. 31) triangular with a medio-longitudinal groove and indication of a transverse step; subapically constricted and sometimes faintly incised; apex rounded. Subgenital plate elongate, apex subpointed. Epiphallus (fig. 59) bridge-shaped; anchorae flexed, in lateral view pointed; outer lophi prolonged with a small lateral bulge, inner lophi rounded-trapezoid. Cingulum with zygoma, rami and apodemes; apodemes upcurved; rami thin-membranous in ventral half; basal and apical penis valves connected by a sharply curved, unbroken flexure.

♀: Supra anal plate long-triangular with sides almost rectangularly sloping; dorsal surface subflat or grooved, with indication of a transverse sulcus. Ovipositor short. Subgenital plate elongate, in apical quarter with indication of lateral carinae between the flat central part and the upcurved lateral areas; apical margin (of disc) subtruncate or lateral corners faintly projecting, with a triangular medial projection.

C o l o r a t i o n . Legs and lateral sides of head, pronotum, pleurae and tegmen in front of subcosta green or yellowish-brown; dorsum of head, pronotum (including dorsal area of paranota), tegmen behind subcosta, face between lateral fascial carinae, and sternal plate varying from medium brown to black; in some ♀ also the anterior area of the tegmen infumate. Hind wings transparent or more or less infumate. Antennae brown with white tips. Hind tibiae darkened towards apex.



FIGS 56-63

56-58. *Dhimbana castanea* n.sp. (holotype), 56. endo- and ectophallus in lateral view, 57. epiphallus in dorsal view, 58. do. in cranial view; 59. *Paragonista hyalina* Ingrisch, epiphallus; 60-61. *Dnopherula svenhedini* (Sjöstedt), 60. endo- and ectophallus, 61. epiphallus; 62. *Dnopherula taeniatus* (Bolivar) from Huei Kaeo, epiphallus; 63. *Truxalis siamensis* Dirsh from Huei Kaeo. Abbreviations: A anchorae, An anterior projections, Ap apical valves of penis, Apd apodemes, B bridge, Bp basal valves of penis, Cv Valves of cingulum, Fx flexure, Gpr gonopore processes, Il inner lophi, Lp lateral plates of basal valves of penis, Ol outer lophi, Os oval sclerites (only drawn on one side), Pp posterior projection, Sps spermatophor sac, Zyg zygoma.

Measurements (length in mm): body ♂ 22 - 25, ♀ 26-33; fastigium (in front of eyes) ♂ 1.3 - 1.5, ♀ 1.5 - 1.7; antenna ♂ 10 - 12, ♀ 9.5 - 11; pronotum ♂ 3.0 - 3.7, ♀ 4.1 - 4.8; tegmen ♂ 16 - 18.5, ♀ 20.5 - 22.5; postfemur ♂ 9 - 10.5, ♀ 11 - 13.

Indices: Width of fastigium : eye length ♂ 0.47 - 0.55, ♀ 0.51 - 0.55; eye length : length of suborbital furrow ♂ 1.83 - 2.13, ♀ 1.73 - 2.00; length of prozona : length of pronotum ♂ 0.56 - 0.60, ♀ 0.57 - 0.59.

Stridulation (fig. 65). The calling song, a prolonged verse, can be described as a "rhrhrhrhrhrh...rt". It lasts between 5 and 10 s (at 25°C plus radiation heat) and comprises about 90 - 170 succeeding echemes. The intensity of the echemes increases at the beginning of the verse. In the laboratory, an isolated male sang up to two times in one minute. But usually the repetition rate is much lower and the song is rarely heard in the field.

Discussion. As the preceding species, *P. hyalina* belongs to the *Mesopses* group (JAGO 1969). The female was hitherto unknown. It differs from the only other species of the genus *P. infumata* C.Willemsse, 1932, by the shape of the frons in lateral view which is slightly concave in *P. hyalina*, straight in *P. infumata*, and a much higher number of stridulatory pegs (126 - 165 in *P. hyalina*, about 100 in *P.*

infumata). The differences in the male sex are already outlined in INGRISCH (1989). In contrast to the original description, the coloration of the hind wings in both sexes can vary from completely hyalinous to strongly infumate. *P. hyalina* lives in the same habitat as *D. castanea*.

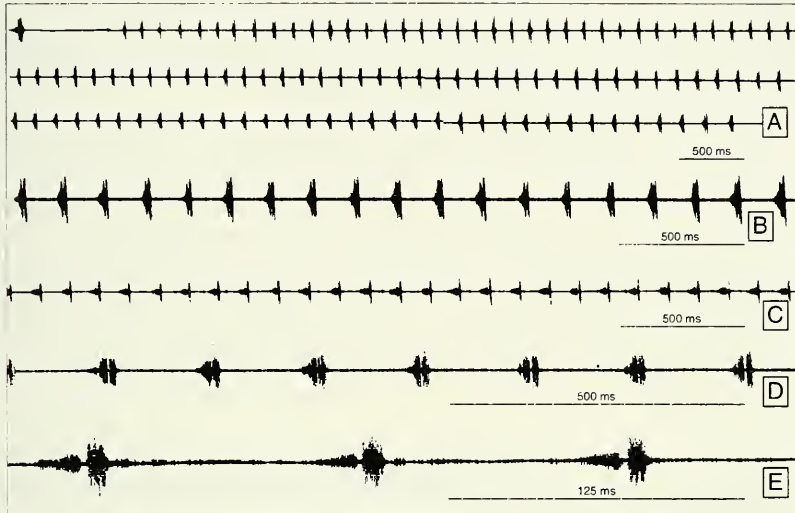


FIG. 64

Calling song of *Dhimbana castanea* n.sp. A. Studio-record of a complete song at 23°C plus radiation heat from a 60 W-bulb; B. Section of A; C. field-record at Huei Kaeo in sunshine after rain (no temperature recorded); D. Section of B; E. Section of C.

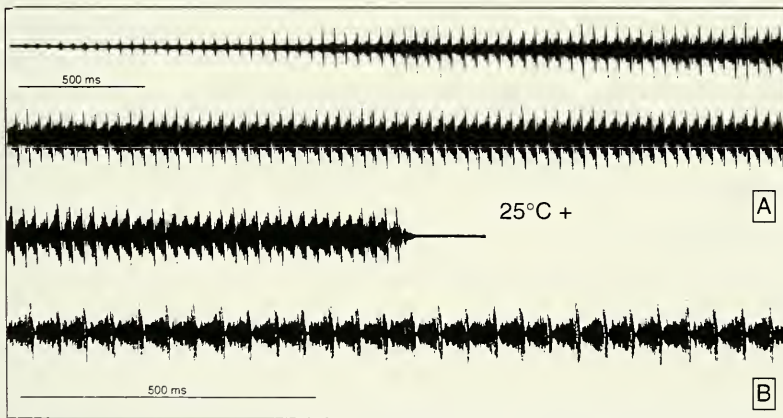


FIG. 65

Calling song of *Paragonista hyalina*. Studio-record of a male from Huei Kaeo at 25°C plus radiation heat from a 60 W-bulb. A. Complete verse; B. Section.

***Dnopherula (Aulacobothrus) taeniatus* (Bolívar, 1902)** (Figs 7-11, 26, 33, 34, 38, 42, 45-48, 62, 66)

Material studied: 1 ♂ (lectotype), India, Kodaikanal ?, (Museo Nacional de Ciencias Naturales, Madrid, Spain). Thailand: 2 ♂, 2 ♀, Chiang Mai province, Huei Kaeo, 12.IV.1985; 2 ♂, 1 ♀, do. 30.IX.1985; 3 ♂, 4 ♀, do. 23.I.1987; 3 ♂, 4 ♀, do. 26.IV.1988; 3 ♂, 4 ♀, do. 3.V.1988; 5 ♂, 1 ♀, do. 10.IX.1989; 1 ♂, do. 23.X.1990; 4 ♂, 7 ♀, do. 23.X.1990 ex larvae; 1 ♂, 6 ♀, do. 23.X.1990 ex ovo; 1 ♂, 3.X.1991; 1 ♂, 1 ♀, do. 8.VIII.1992; 4 ♂, 4 ♀, Sukothai province, ancient town, 12.V.1988; 6 ♂, 2 ♀, Kanchanaburi province, near Pha That Cave, 2.VI.1988; 2 ♂, 2 ♀, Chon Buri province, Pattaya, 4.IV.1985; 2 ♂, Petchaburi province, Khao Wang, 7.II.1987; 4 ♂, 3 ♀, Prachuap Khiri Kan province, Hua Hin, 26.VII.1992.

Description. Antennae slightly flattened in circa basal third, longer than head and pronotum together and slightly surpassing base of postfemur. Frontal ridge with subparallel sides. Fastigial foveolae oblong. Pronotum (figs 7-11) with lateral carinae variable: straight or slightly diverging before second sulcus, sometimes irregular or absent between second and third sulcus, diverging posteriorly behind third sulcus. Tegmen (figs 45-47, 48) variable in length and in width of apical area, costal and cubital fields widened in ♂. Mesosternal interspace (fig. 38) varying from almost as wide to almost only half as wide as mesosternal lobes; metasternal lobes contiguous (♂) or narrowly separate (♀). Tympanum 1.4 - 2.1 x longer than wide. Postfemur moderately stout; with a row of (70 -) 94 - 126 (♂) or 75 - 121 (♀) stridulatory pegs on internal surface (variation in the Huei Kaeo population ♂ 70 - 126, ♀ 75 - 113). Posttibiae with external apical spine lacking; ventral interno-apical spur moderately longer than dorsal.

♂. Tenth tergite divided, varying from separate to subcontiguous (figs 33, 34). Supra anal plate weapon-shaped; lateral margins upcurved in circa basal half, constricted subapically with constriction either concavely rounded (fig. 33) or incised, in the latter case with a small tooth at the base of the constriction (fig. 34); apex rounded. Epiphallus (fig. 62) bridge-shaped, ancorae with apex acute, inner lophi larger than outer. Penis valves flexured.

♀. Ovipositor short, simple. Subgenital plate with sinuate apex (fig. 42).

Coloration. Grey or different shades of brown. Four colour variants: (1) uniform throughout, irregularly mottled; (2) dark with a narrow, pale, dorso-medial stripe; (3) dorsal parts of head, pronotum and tegmen of pale colour, head and paranota with a dorso-lateral dark band; (4) quadrimaculate: irregularly mottled, disc of pronotum with a dark spot at each corner. Hind knees darkened; posttibia reddish, yellowish at base.

Measurements (length in mm): body ♂ 12 - 19 (15 - 19), ♀ 19 - 30; pronotum ♂ 2.5 - 3.8 (3.0 - 3.8), ♀ 3.9 - 5.1; tegmen ♂ 10 - 15 (12 - 15), ♀ 14 - 21; postfemur ♂ 7.5 - 11.5 (9.0 - 11.5), ♀ 11.0 - 16.0. The values in brackets are those of the Huei Kaeo population (♂ only); in ♀, the full range of measurements occurs in this population.

Indices (the full range of variation can be found within the Huei Kaeo population): Width of fastigium : eye length ♂ 0.34 - 0.47, ♀ 0.43 - 0.50; eye length : length of suborbital furrow ♂ 2.36 - 3.30, ♀ 2.00 - 2.64; length of prozona : length of pronotum ♂ 0.49 - 0.55, ♀ 0.48 - 0.54; length of apical field of tegmen : length of tegmen ♂ 0.21 - 0.32, ♀ 0.22 - 0.34.

Stridulation (fig. 66). Stridulation can be described as a "tr drhrhr...hrhhh" (using a guttural "r"). The calling song starts with a single tick sound which is immediately followed by a sequence of up to 24 echemes. Within an echeme, the intensity increases from the start. The syllable structure of the echemes is not very clear on the oscillograms due to fast leg movement, but there is always a louder pulse at the end of an echeme, lacking only in the last echeme. The number of echemes per verse is somewhat variable. In the studio and in the field, isolated males produced between 9 and 24 echemes per verse. There is a tendency towards a reduction in the number of echemes per verse, if a male has acoustical contact with other males. In the typical rivalry song, the number of single pulses at the beginning of the verse can be increased and the number of echemes is usually reduced to 3 or 5 per verse. Intermediate songs between the rivalry and the calling song were also recorded. No differences in stridulation were observed between males with straight or with somewhat angular lateral carinae in the prozona of the pronotum, nor between males with different length of the apical area of the tegmen. Slight variations in song duration at similar ambient temperature as shown in fig. 66 are due to differences in the distance of the singing male from the heat source, a 60 Watt bulb.

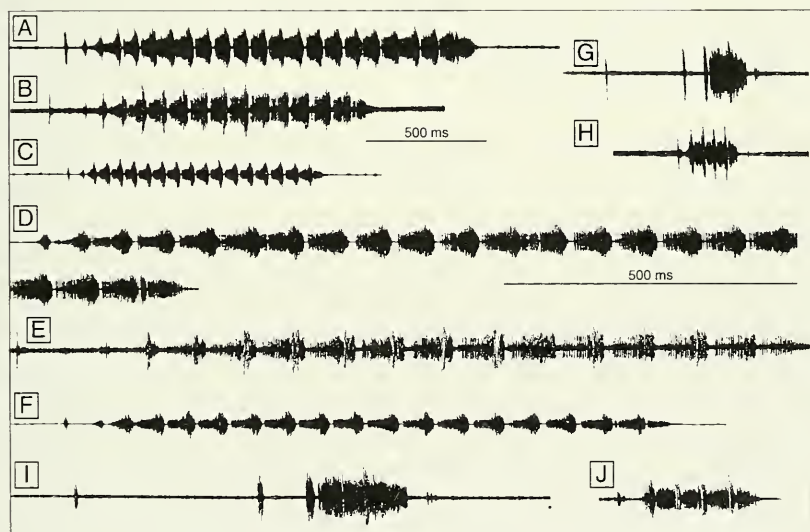


FIG. 66

Stridulation of three males of *Aulacobothrus taeniatus* from Huei Kao (studio records). A - F. Calling songs; G - J. Rivalry songs; A, D. male with diverging lateral carinae of prozona in pronotum; B, E. male with straight lateral carinae in prozona of pronotum; C, F. male (ex ovo) with diverging lateral carinae in prozona of pronotum; G, I. male with diverging lateral carinae responding to song of male with diverging lateral carinae; H, J. male with straight lateral carinae responding to song of male with diverging lateral carinae. Records at 25°C plus radiation from a 60 W-bulb (G, I at 23°C).

D i s c u s s i o n . The genus *Aulacobothrus* BOLIVAR, 1902 was reduced to subgeneric rank in the genus *Dnopherula* KARSCH, 1896 by JAGO (1971); *Aulacobothrus* contains most of the Asiatic, *Dnopherula* s.str. mainly African members of the genus.

D. taeniatus BOLIVAR, 1902 has been confused with *D. luteipes* (WALKER, 1871) since UVAROV (1921). However, wing venation of the types of both taxa differ so strikingly that they cannot be regarded as belonging to the same species. The relative size of the head, the position of the principal sulcus of the pronotum and the apex of the female subgenital plate are further diagnostic characters separating both species. A more detailed account of the differences will be given elsewhere (INGRISCH, in press). *D. luteipes* has a rather local distribution in India, while *D. taeniatus* is widespread in India and Indochina.

D. taeniatus is a highly variable species. A fact already emphasized by UVAROV (1929: as *D. luteipes*). The variation is most striking with regard to the course of the lateral carinae of the pronotum, the size and venation of the tegmen (especially the width of the medial and cubital fields and the length of the apical area), coloration, and the shape of the supra anal plate of the male. As all the different forms can occur within the same population, for example in the mixed forest-savanna near the Huei Kaeo waterfall outside Chiang Mai, as they all produce the same songs, and as the males of different forms respond to each other with rivalry songs, there is no doubt that they are conspecific.

Dnopherula (Aulacobothrus) svenhedini (SJÖSTEDT, 1933) (Figs 12-16, 23, 24, 27-29, 32, 35, 39, 40, 43, 44, 49, 50, 60, 61, 67)

Material studied: 1 ♂ (holotype), China, NE Szechuan, lg. Hummel (Naturhistoriska Riksmuseet, Stockholm). 10 ♂, 10 ♀, Thailand, Loei province, Phu Kradung, 28.V.1988; 4 ♀, do., 8.III.1948, lg. Chainarang (Lot 1430, Department of Agriculture Bangkok).

D e s c r i p t i o n . Antennae longer than (♂) or as long as (♀) head and pronotum together, segments compressed in basal, subcylindrical in apical half. Foveolae visible from above, longer than broad, shallow (figs 12, 14). Disc of pronotum (figs 12-15) with a prominent median carina cut by the principal sulcus only. Lateral carinae cut by sulci 2 - 4, from substraight to distinctly diverging anteriorly in front of the 2nd sulcus, distinctly diverging posteriorly behind the 3rd sulcus. Tegmen slightly surpassing apex of stretched postfemur; rather wide until apex, venation as in figs 49-51. Mesosternal interspace (figs 39-40) narrower than mesosternal lobes, slightly or distinctly deviating posteriorly; metasternal lobes subcontiguous. Tympanum 1.4 - 1.6 times longer than wide. Postfemur moderately stout, inner side with a row of 77 - 112 (♂) or 73 - 104 (♀) stridulatory pegs; genicular lobes rounded. Posttibia with 10 dorso-external (apical spine lacking) and 12 - 13 dorso-internal (including apical spine) spines.

♂. Tenth tergite divided. Supra anal plate (fig. 32) ovoid-triangular, lateral margins upcurved in basal half, with indications of a basal medial furrow and a transverse sulcus, apex unmodified. Cerci conical. Subgenital plate short (fig. 28).

Epiphallus (fig. 61) bridge-shaped, coracae with apex rounded, inner and outer lophi almost equal in size. Cingulum (fig. 60) with zygoma, rami and apodemes; apodemes rather short, rami thin-membranous in ventral half and apically connected with a thin membrane covering bases of cingular valves and apical penis valves. Basal and apical penis valves connected by a sharply curved, unbroken flexure.

♀. Supra anal plate lingulate (fig. 35). Cerci conical. Ovipositor short, simple. Apex of subgenital plate blunt-triangular with margins straight or slightly concave and tip rounded.

C o l o r a t i o n . Brownish-grey, mottled with darker spots; dorsal side usually darker than face, lower part of genae, ventral margin of pronotum and underside, or reddish brown. Three colour variants were collected: (1) dorsal side dark with a narrow pale, medial band on head, pronotum and tegmen; (2) dorsal surface completely pale and with broad dark, dorso-lateral bands; (3) uniformly and indistinctly mottled. Tegmen translucent with brown spots, especially in the medial area; hind wings transparent, apex infumate. Postfemur on dorso-external area with a more or less distinct dark brown spot before the middle followed or not by a brown stroke, ventro-external carina with dark dots, internal and ventro-internal areas red, yellowish towards apex; a pregenicular ring yellowish brown, hind knees more or less infumate. Posttibia with basal third yellowish-brown, apical two thirds and tarsi reddish.

M e a s u r e m e n t s (length in mm): body ♂ 16 - 18, ♀ 20 - 22; pronotum ♂ 2.9 - 3.2, ♀ 3.5 - 3.9; tegmen ♂ 13.5 - 15.0, ♀ 16.5 - 18.0; postfemur ♂ 9.5 - 11.0, ♀ 12.0 - 13.5.

Indices: Width of fastigium : eye length ♂ 0.35 - 0.39, ♀ 0.38 - 0.44; eye length : length of suborbital furrow ♂ 2.44 - 2.95, ♀ 2.13 - 2.50; length of prozona : length of pronotum ♂ 0.47 - 0.50, ♀ 0.46 - 0.49; length of apical field of tegmen : length of tegmen ♂ 0.26 - 0.32, ♀ 0.27 - 0.33.

S t r i d u l a t i o n (fig. 67). Only a few field observations were possible during some minutes of sunshine in otherwise cloudy weather. Two different types of songs were heard. Usually the males produced rather quiet and short verses of about 1 s, consisting of a single echeme of about 14 - 20 pulses (fig. 67, A first row and D). The resulting sound can be described as a "drrrrr". Once, this short song was immediately followed by a long song of alternating quiet and loud echemes (fig. 67 A). The sound can be described as a "rr(ou)h drre rr(ou)h drre". This song lasted for 11 s and comprised 15 loud and 17 quiet echemes (starting with one and ending with two quiet echemes). Both types were of about equal duration. The loud echemes started with a haplo-syllable (one-pulse-syllable) which was followed by 4 - 6 diplo-syllables (two-pulse syllables); the pattern of the quiet syllables is less clear.

D i s c u s s i o n . This species was previously only known from China. In Thailand, a single locality is known, the plateau of Phu Kradung at about NN + 1500 m. The habitat is a mixed grassland-shrub savanna with scattered pine trees on poor soil as indicated by the occurrence of many pitcher plants and *Drosera*. Most grasshoppers were found sitting on sandy roads.

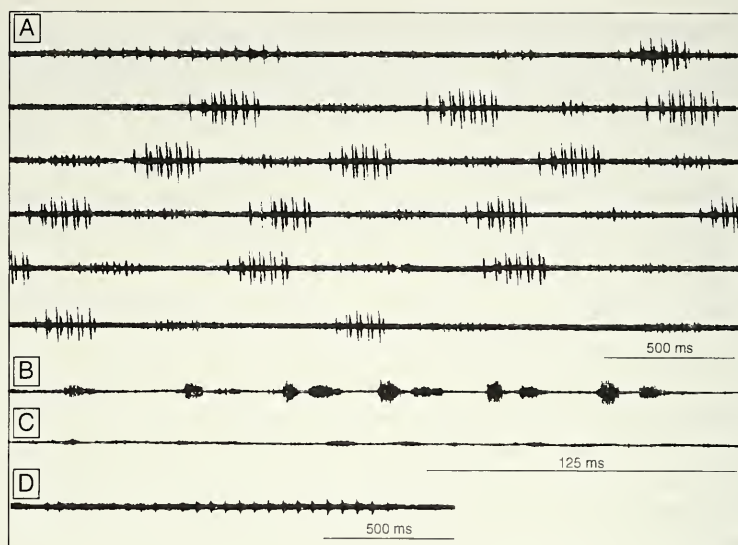


FIG. 67

Field record of the calling song of *Dnopherula svenhedini* (Sjöstedt) at Phu Kradung in sunshine (temperature above 20°C, not measured exactly). A. Short song followed by a long song; B. one loud echeme of the long song; C. one quiet echeme of the long song; D. separate short song.

Truxalis siamensis Dirsh, 1950

(Figs 17-20, 25, 41, 63, 68)

Material studied: 1 ♂, 1 ♀ (topotypes), Prachuap Khiri Kan province, Hua Hin, hill near golf course, 26.VIII.1992 ex larvae; 1 ♂, 1 ♀, do. 1.IV.1993; 2 ♂, Chiang Mai province, Huei Kao, 3.V.1988; 1 ♂, 2 larvae (♂ + ♀ last instars), do. 23.X.1990 ex larvae; 1 ♀, do. 4.IV.1993; 1 ♂, Loei province, Phu Kradung, 26.VIII.1975, lg. G. Minet (Naturhistorisches Museum Basel).

Description. Antennae with segments 3 to 8 or 9 (♂) respectively 3 to 11 (♀) compressed and moderately widened. Fastigium (fig. 17, 25) extending 1.7 - 2.0 mm (♂) or 2.3 - 2.7 mm (♀) in front of front margin of eyes, parallel sided, apex rounded-angulate. Pronotum (fig. 18) circa parallel-sided in prozona, faintly (♂) or distinctly (♀) saddle-shaped in metazona; lateral carinae substraight (♂) or slightly sinuate (♀) in prozona, more or less diverging in metazona; principal sulcus from slightly before to slightly behind middle of pronotal length (index prozona : pronotum = 0.48 - 0.54); posterior margin triangular, apex rounded, sides straight or faintly concave. Tegmen 8.3 - 10.3 x (♂) or 9.5 - 10.6 x (♀) longer than broad. Mesosternal lobes 2.8 - 3.5 times wider than mesosternal interspace at the smallest point. Tympanum 1.6 - 2.2 x longer than broad.

Interior side of postfemur with a row of 130 - 163 bristles (♂ + ♀) almost over the whole length of the femur, all pointing apico-internally (figs 19, 20). At both sides some bristles are largely spaced and sit on very tiny pegs or rise directly from the

surface of the femur, towards the center of the row they sit on pegs of gradually increasing size. The pegs are most dense at the end of the basal third of the postfemur. Obviously this part is mainly used for stridulation, as the bristles are short, i.e. used and partly broken.

♂: Tenth tergite divided-contiguous. Supra anal plate lingulate, almost semicircular, with a medio-longitudinal groove and a transverse sulcus in about middle of length, both usually very faint, apex rounded. Cerci conical, apex obtuse. Subgenital plate with a long basal and short apical part, apex sub-pointed. Epiphallus bridge-shaped (fig. 63), ancorae with apex rounded, inner lophi slightly larger than outer lophi. Cingulum with zygoma, rami and apodemes; zygoma prolonged with a curvature on each of its apico-lateral corners; rami thin-membranous throughout; basal and apical penis valves connected by a curved, unbroken flexure.

C o l o r a t i o n . Different shades of brown with green ornaments. Narrow apical part of antennae white. Genae with a white stripe below compound eyes. Tegmen of type 4 in DIRSH (1950), with a white and a black stripe in cubital area, the latter more or less serrated at anterior margin. Hind wings red.

M e a s u r e m e n t s (length in mm): body ♂ 37 - 46, ♀ 61 - 65; antennae ♂ 14.5 - 17.5, ♀ 20 - 22; pronotum ♂ 6.0 - 6.4, ♀ 9.6 - 10.1; tegmen ♂ 30 - 37, ♀ 52; postfemur ♂ 23 - 28, ♀ 34 - 37.

S t r i d u l a t i o n (fig. 68). The songs of one male from each, Hua Hin (locus typicus) and Huei Kaeo, were recorded. Stridulation is rather scarce. The male from Hua Hin stridulated at intervals of between 1 and 5 minutes when the singing activity was high. Sometimes two successive verses were produced at an interval of 10 - 30 s. Both males were often silent for hours or even during the whole day.

In both males, the speed of the calling song was rather variable even at the same ambient temperature. It obviously depended on the distance of the male from the 60-Watt bulb which was a source of radiation heat. It lasted from about 1.3 to 2.5 s ($n = 18$) in the ♂ from Huei Kaeo and from 1.6 to 2.1 s ($n = 22$) in the ♂ from Hua Hin. The sound can be described as "dr dr dr ...". The calling song is a single verse which consists of 6 - 14 echemes (6 - 14 in the ♂ from Huei Kaeo, 11 - 14 in the ♂ from Hua Hin). One echeme usually contains 3 or 4 syllables, but the number may be lower at the start or the end of a verse. In the ♂ from Huei Kaeo four-syllabic echemes (106 of 186) and in the ♂ from Hua Hin three-syllabic echemes (175 of 278) prevailed. The duration of an echeme varied between 134 and 313 ms in the ♂ from Huei Kaeo and between 125 and 177 ms in the ♂ from Hua Hin.

Discussion. The species was originally described after a female (the type) from Hua Hin and a pair of uncertain origin. According to the description and figures in DIRSH (1950), the principal sulcus of the pronotum should be located in or slightly before the middle of the pronotum. Recently, LIANG (1989) described a new species, *T. guangzhouensis*, from southern China. The differences were said to be (1) the sulcus lying behind the middle of the pronotum and (2) some faint differences in the very tip of the male subgenital plate. The specimens from northern Thailand agree more with the description given by LIANG (1989) than with the description in DIRSH (1950), as the prozona of the pronotum is 1.05 - 1.2 x longer than the metazona. The

apex of the male subgenital plate of one male from Huei Kaeo agrees with the figure in DIRSH (1950), that of a second male from the same locality with the figure in LIANG (1989). In specimens from the type locality in Hua Hin, the index prozona : metazona varies from 0.9 - 1.1. In contrast to the description in DIRSH (1950), the prozona can thus be either longer or shorter than the metazona. In the living male, the subgenital plate is even more pointed than in the figure 116 in DIRSH (1950).

As the stridulation of the males from Hua Hin and Huei Kaeo is identical, both populations must be regarded as conspecific. The variation of *T. siamensis* is thus much larger than previously supposed. The status of *T. quangzhouensis* should be re-examined.

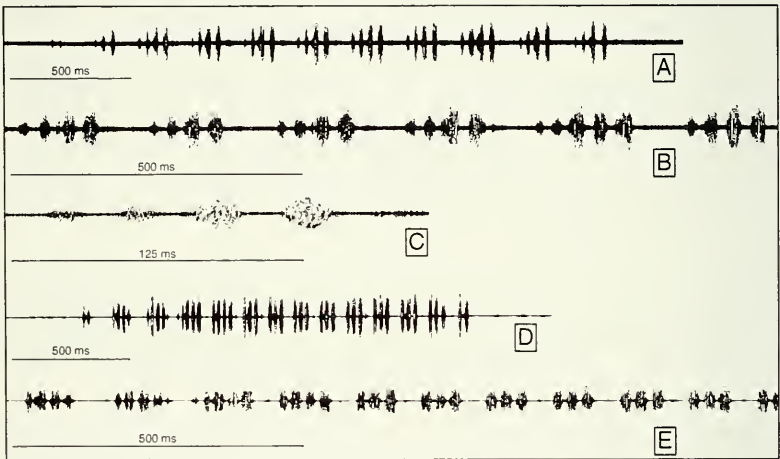


FIG. 68

Studio record of the calling song of *Truxalis siamensis* Dirsh at 25°C plus radiation heat from a 60 W-bulb. A - C. male from Huei Kaeo sitting remote from the 60 W-bulb; D - E. male from Hua Hin sitting close to the 60 W-bulb. A, D. complete verse; B, E. section; C. single echeme.

T. siamensis has one generation per year. Larval development is prolonged and lasts from the middle of the rainy season to the end of the dry season (July - April). Adults appear at the end of the dry and the beginning of the rainy season, mainly in April and May.

ACKNOWLEDGEMENTS

The oscillograms were done at the Zoological Institut Erlangen; I am grateful to Prof. Dr. O. von Helversen and Dr. K.-G. Heller (Erlangen) for providing room and equipment. Thanks go also to Dr. K. Tschudi-Rein (Zurich) for helpful criticism on the style of the manuscript.

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